A Study on The Current Aspects of Dredging in Bangladesh and Estimation of Production Rate of a Cutter Suction Dredger

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DECLARATION

It is hereby declared that this thesis work entitled **"A Study on The Current Aspects of Dredging in Bangladesh and Estimation of Production Rate of a Cutter Suction Dredger"** has been done under the supervision of Dr.Mir Tareque Ali, Professor, Department of Naval Architecture and Marine Engineering, Bangladesh University of Engineering and Technology, Dhaka. This thesis is a presentation of the original research work. Any part of this thesis or the results generated by the research has not been submitted or accepted to any certification or competition.

Prof. Dr.Mir Tareque Ali

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Finally, we want to dedicate this work to our wonderful parents for their support, care and encouragement in the progress of our work.

ABSTRACT

Bangladesh is a riverine and densely populated country with approximately 700 rivers. So, dredging plays a vital role in Bangladesh. Water transport is the cheapest means of transport and communication in our country, because 60% of the population is below the poverty line and lives in the rural areas. So improvement of IWT is a necessity for the economic development of our country. But the rivers and canals are reducing day by day due to silting by sand and clay deposits and the result is directly affecting the waterways. In this situation it is very much essential to improve the waterways for socio- economic development of the country. Two types of dredging programs naming Maintenance Dredging and Development Dredging are generally used to improve the navigability of the inland waterways. To bring back navigability in rivers, Government has also been formulating a 50-year mega plan which will be implemented in 3 phases: Short-term, Mid-term and Long-term. Moreover, capital dredging projects are also undertaken by the Govt. Land reclamation is also an important aspect to our country's problem of accommodating the growing population boom. Land reclamation should commensurate with the dredging work to make full advantage of both. A large number of dredgers are needed to fulfil the dredging target. For this, a number of dredger procurement projects are undergoing. In order to monitor the implementation of the dredging projects perfectly, especially, pre-dredging and post-dredging investigations and surveys should be conducted properly. Otherwise, proper outcome will not be obtained at the cost of huge public money.

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1.Introduction

Background of the study

Inland water transport plays a vital role in the transport and communication system in Bangladesh. As a dense network of rivers, canals, creeks criss-crossing the whole area of the country, they provide the cheapest means of transport and communications and in some areas they are the only means of transport. The topographic, soil and climatic conditions in Bangladesh are such that costs of building and maintenance of road and railways are very high compared to those of Inland Water Transport (IWT).Water transport is also a stable and reliable means of transport for the country both in times of peace and natural calamities e.g. flood, cyclone etc. Moreover, IWT is rural in character as it reaches many outlying rural populations that are impossible or very difficult to reach by roads and railways. An estimated 60% of the population in Bangladesh is below the poverty line and most of them live in the rural areas. Development of IWT is, therefore, very essential for effective and successful implementation of economic development program and alleviation of poverty in the country.

Role of Inland Water Transport and Dredging

Inland Water Transport has a great impact in poverty reduction. A significant amount of people living in rural area has still no scope to access road transport and they are directly dependent on IWT services. The percentage of households which have access to river transport is 25.1 percent. This is quite high for a 24,000km long network which is much shorter than the road network. Although the road network is 274,000 km long, only 37 percent of rural households live within

two kilometres (generally 20-25 minutes walking distance) of an all-season road. As well as, to make road transport, cultivable land is required, while waterways as a gift of nature does not impact any land area. Unfortunately, the rivers and canals are going to be reduced day by day due to stream flow reduction in cross boundary flow, silting up of off takes and reduction of tidal volume and the result is directly affecting the waterways. The length of IWT network has been declined to 6000 km (maintained by Bangladesh Inland Water Transport Authority (BIWTA), the rest 20,000 used for irrigation, fisheries, drainage and flood control are maintained by Bangladesh Water Development Board (BWDB)) during monsoon and 3800 km during dry season from 8400 km and 5200 km, respectively as per the Bangladesh Integrated Transport Sector Study, 1998. Moreover it is blocking the drainage capacity of flood water, thus worsening the whole economic condition of the country. For this reason, to maintain socio economic growth it is essential to mend the waterways

Literature Review

The early work by Michael Wayne Miertschin on Cost and Production Estimation of Cutter Suction Dredge [9] has been the topic of interest. From the above thesis ,we have taken the production rate estimation part for our thesis. Regarding the current overview of dredge and land reclamation of Bangladesh[8], already a thesis is done by Papia Sultana, Md Mezbah Uddin, Mohammad Irfan Uddin, Md Abir Hossain. The annual dredge demand, dredge fleet, maintenance, crew data has been taken from BIWTA[7] and BWDB[8] website. We used information from articles of different newspaper [2-6] on ongoing dredging project and problems.

Objectives

- Study on different types of dredging.
- Study on current scenario of dredging sectors both abroad and Bangladesh.
- Finding out the problems related to dredging in our country.
- Finding the way of solving these problems and try to increase the current overall efficiency.
- Finding the specification of a Cutter Suction Dredger for a required project.
- Estimating production cost of a Cutter Suction Dredger.

Dredging

Dredging is the operation of removing material from one part of the water environment and relocating it to another[1].It is carried out underwater or partially underwater, in shallow waters or ocean waters. Possible purposes of dredging include: improving existing water features; reshaping land and water features to alter drainage, navigability, and commercial use; constructing dams, dikes, and other controls for streams and shorelines; and recovering valuable mineral deposits or marine life having commercial value. In all but a few situations the excavation is undertaken by a specialist floating plant, known as a dredger.The general dredging procedure is shown is figure 01:

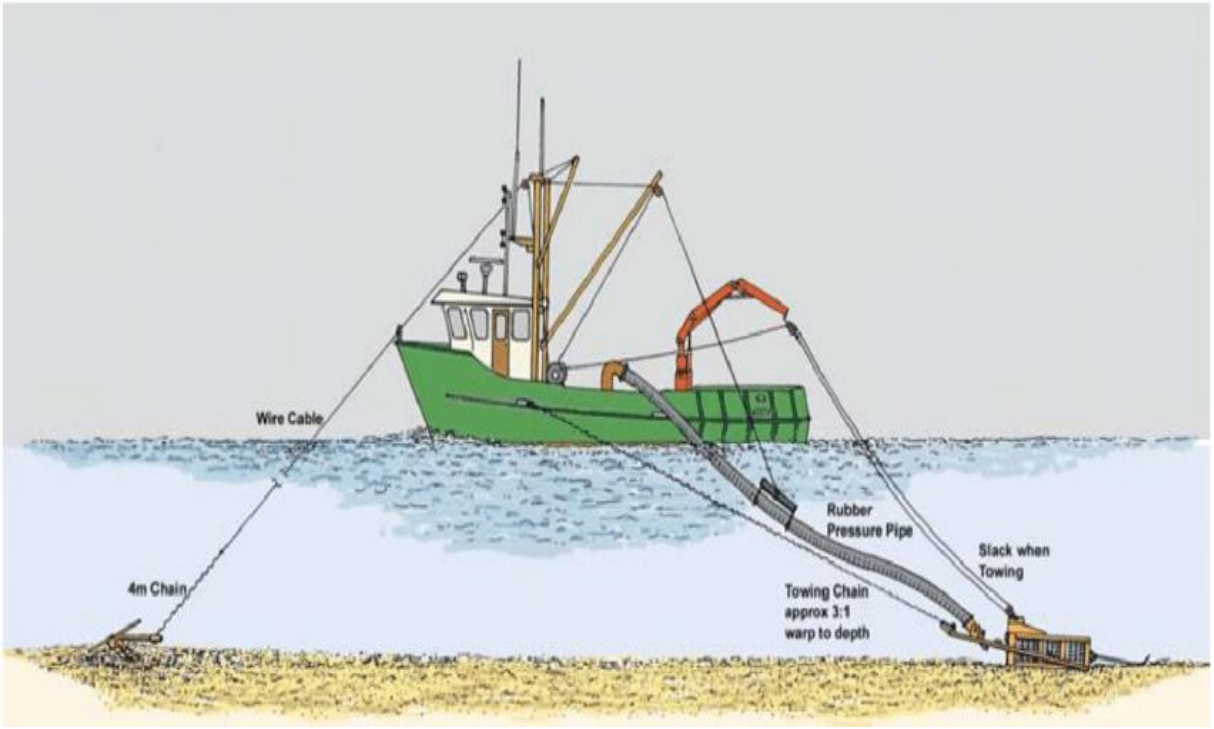

Figure 01:Dredging

Dredging Purposes

Capital dredging:It is carried to create a new harbor, berth or waterway or to deepen existing facilities in order to allow larger ships access. Because capital works usually involve hard material or high-volume works, the work is usually done using a cutter suction dredge or large trailing suction hopper dredge; but for rock works, drilling and blasting along with mechanical excavation may be used.

Land reclamation: Dredging is done to mine sand, clay or rock from the seabed and using it to construct new land elsewhere. This is typically performed by a cutter-suction dredge or trailing suction hopper dredge. The material may also be used for flood or erosion control.

Maintenance:Dredging is done due to sedimented sand and mud, possibly making them too shallow for navigation. This is often carried out with a trailing suction hopper dredge. Most dredging is for this purpose, and it may also be done to maintain the holding capacity of reservoirs or lakes.

Harvesting materials: Dredging sediment for elements like gold, diamonds or other valuable trace substances. Hobbyists examine their dredged matter to pick out items of potential value, similar to the hobby of metal detecting.

Fishing dredging: It is a technique for catching certain species of edible clams and crabs. In Louisiana and other American states, with salt water estuaries that can sustain bottom oyster beds, oysters are raised and harvested. A heavy rectangular metal scoop is towed astern of a moving boat with a chain bridle attached to a cable. This drags along the bottom scooping up oysters. It is periodically winched aboard and the catch is sorted and bagged for shipment.

Winning construction materials: Dredging sand and gravels from offshore licensed areas for use in construction industry, principally for use in concrete. This very specialist industry is focused in NW Europe, it uses specialized trailing suction hopper dredgers self discharging the dry cargo ashore. Land based old river beddings can be processed in this manner too.

Contaminant remediation: To reclaim areas affected by chemical spills, storm water surges (with urban runoff), and other soil contaminations, including silt from sewage sludge and from decayed matter, like wilted plants. Disposal becomes a proportionally large factor in these operations.

Flood prevention: Dredging increases the channel depth and therefore increase a channel's capacity for carrying water.

Removing rubbish and debris: Dredging often done in combination with maintenance dredging, this process removes non-natural matter from the bottoms of rivers and canals and harbors. Law enforcement agencies sometimes need to use a 'drag' to recover evidence or corpses from beneath the water

Different types of Dredgers

Trailing suction Dredger:A trailing suction hopper dredger (TSHD) trails its suction pipe when working. The pipe, which is fitted with a dredge drag head, loads the dredge spoil into one or more hoppers in the vessel. When the hoppers are full, the TSHD sails to a disposal area and either dumps the material through doors in the hull or pumps the material out of the hoppers. Some dredges also self-offload using drag buckets and conveyors

Bucket dredger:A bucket dredger is equipped with a bucket dredge, which is a device that picks up sediment by mechanical means, often with many circulating buckets attached to a wheel or chain

Grab dredgers: A grab dredger picks up seabed material with a clam shell bucket, which hangs from an onboard crane or a crane barge, or is carried by a hydraulic arm, or is mounted like on a dragline. This technique is often used in excavation of bay mud. Most of these dredges are crane barges with spuds, steel piles that can be lowered and raised to position the dredge

Water injection: A water injection dredger uses a small jet to inject water under low pressure (to prevent the sediment from exploding into the surrounding waters) into the seabed to bring the sediment in suspension, which then becomes a turbidity current, which flows away down slope, is moved by a second burst of water from the WID or is carried away in natural currents.[Figure 02] Water injection results in a lot of sediment in the water which makes measurement with most hydrographic equipment (for instance: singlebeam echosounders) difficult.

Backhoe/dipper dredgers: A backhoe/dipper dredger has a backhoe like on some excavators. A crude but usable backhoe dredger can be made by mounting a land-type backhoe excavator on a pontoon. The six largest backhoe dredgers in the world are currently the Vitruvius, the Mimar Sinan, Postnik Yakovlev (Jan De Nul), the Samson (DEME), the Simson and the Goliath (Van Oord). They featured barge-mounted excavators. Small backhoe dredgers can be track-mounted and work from the bank of ditches. A backhoe dredger is equipped with a half-open shell. The shell is filled moving towards the machine. Usually dredged material is loaded in barges. This machine is mainly used in harbours and other shallow water.

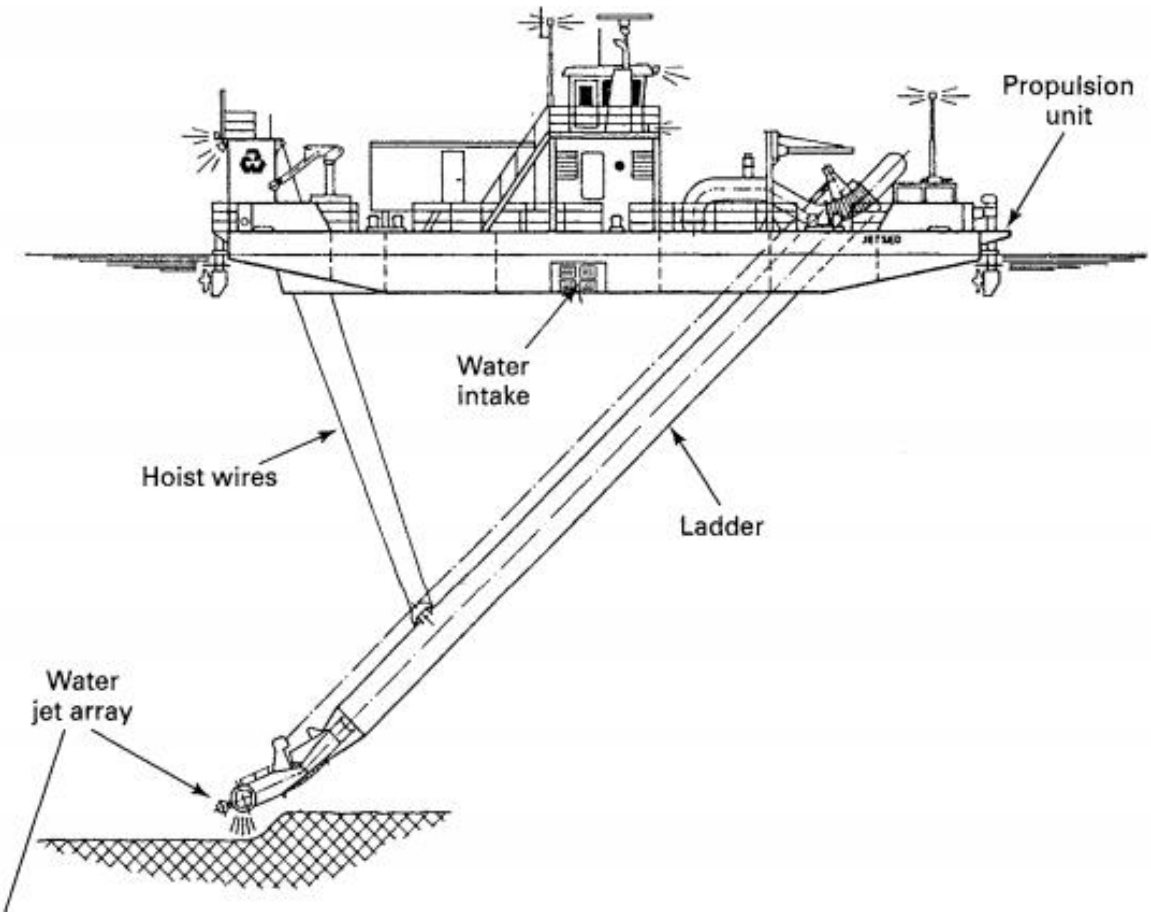

Figure 02 : Water injection dredger

2.Specification of a Cutter Suction Dredger(CSD)

Among all the dredgers, Cutter Suction Dredger(CSD) is mainly used in our country.So, we focused our thesis on the production rate estimation for a CSD.

A cutter suction dredger is a self-propelled or stationary vessel that uses a rotating cutter head to loosen the material in the hard ground.The cutter suction dredger is of dismountable structure, and can be divided into mechanical type, semi-hydraulic type, all-hydraulic type according to the different operating methods.

The main advantages of the dredger are:

- Ability to dredge a very wide range of materials, including rock, and to convey the dredged material by pumping with water directly to the disposal, or reclamation area;
- Ability to operate in shallow water and to produce a uniform level bottom with high rates of production;
- Ability, in the case of some modem dredgers to dredge to a pre-defined profile, e.g. in channels.
-

Below given diagram of a Cutter Suction Dredger

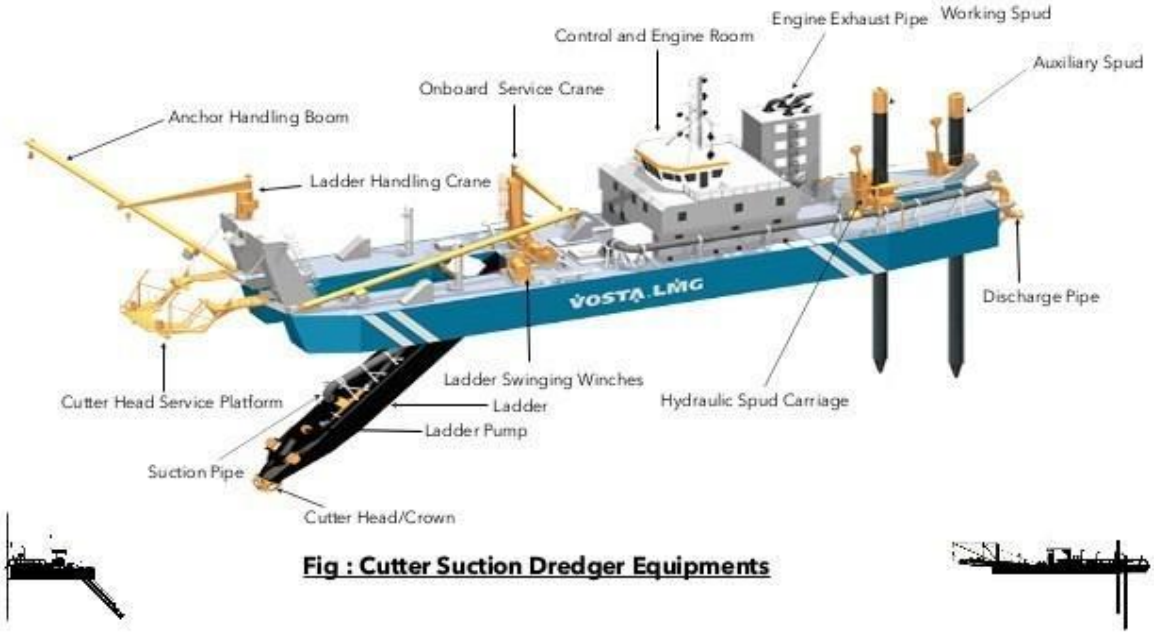

Fig 03: Cutter Suction Dredger

During the dredging works, a spud is lowered in the seabed to secure the vessel. As a result, it is kept on the same location, but by using winches and anchors, the dredger swings sideways and the cutter head cuts and removes the soil.Dredging pump is driven by main diesel engine placed in the main pontoon, and auxiliary engine will provide power to cutter head, winches, spuds and lighting system.

Method of Operation

The soil or rock to be dredged is cut, dislodged, or broken, by a powerful crown cutter. The cutter typically has five or six plain edged or toothed blades according to the ground conditions

- The cutterhead may be electrically or hydraulically driven. It encloses the suction intake pipework of a centrifugal dredge pump.The cutterhead is mounted at the extremity of a fabricated steel structure, called a ‘ladder’, which also supports the suction pipe
- The ladder is attached to the main hull by heavy hinges which permit rotation in the vertical plane. The suction pipe includes a length of heavy reinforced hose which imparts the flexibility necessary to permit rotation. The hose is located immediately outside the pump- room bulkhead

- The main pontoon structure contains the dredge pump or pumps, the main engines and all ancillary engines, drives and equipment. Generally, small dredgers are diesel hydraulic and large ones diesel electric. For improved performance, or greater dredging depth, a submerged dredge pump may be mounted on the ladder, usually in combination with one or two inboard pressure pumps.

3.Methodology

- Taking information from different dredging related articles and journals.
- Meeting with responsible persons for different dredging projects.
- Analyzing all of our information.
- Using different empirical formula to determine the production rate and analyzing effect of different factors.

Current aspects of dredging in Bangladesh:

- Under Delta Project -2100,Bangladesh Govt. is planning to bring back the navigability of major rivers
- To implement this project,36356 million m^3 dredging is needed in 23 big rivers
- A Total of 216 CSD dredgers and 800 ancillary crafts will be needed[9]
- Recently under the project "Procurement of 20 dredger and ancillary equipments" BIWTA has purchased 20 new cutter suction dredger and 58 ancillary craft boats.[7]

Dredging Programs

To improve the navigability of inland waterways, BIWTA has undertaken two types of dredging programs:

1.Maintenance Dredging

2.Development Dredging.

Maintenance dredging is the kind of dredging that is done in every year to maintain the rivers used for watercrafts to ply. Development dredging is the dredging conducted to excavate the sediment from a river almost dead in order to make the river alive with navigability of definite draft.In order to assess dredging work an accurate estimate and evaluation of the volumes and nature of the materials to be excavated or dredged must be done conspicuously. A geotechnical survey with laboratory test results and samples and a detailed design layout showing areas to be excavated and the design depths are required along with the relevant cross-section to estimate the volume of work. Also physical, chemical & biological characteristics of materials need to be

evaluated beforehand of carrying dredging work. Moreover, land reclamation should commensurate with the dredging to get full benefit of the same.

Dredging Work (Maintanace):

Target(lacs m3)		Progress (lacs m3)		Total Development
BIWTA	Private	BIWTA	Private	
116.70	108.75	74.60	78.42	152.96

Table 01 : Maintenance dredging work

Dredging Work(Development) :

Target(lacs m3)		Progress(lacs m3)		Total Development
BIWTA	Private	BIWTA	Private	
35.70	291.75	52.70	254.05	306.75

Table 02: Development Dredging work

Dredging data of BIWTA's current fleet:

Serial No	Dredger Name	Purchase Year	Dredging Capacity(lacs m3 yearly)	Status
1	Delta 1	1972	3	Rehabilitated
2	Delta 2	1972	3	End of economic life
3	Dredger 135	1975	4	End of economic life
4	Dredger 136	1975	4	End of economic life
5	Dredger 137	1975	4	End of economic life
6	Dredger 138	1975	4	End of economic life
7	Dredger 139	1975	4	End of economic life
8	Dredger Karnaphuli	2011	6	Collected in 2011
9	Dredger Kushiara	2011	6	Collected in 2011
10	Dredger Kopotakkha	2011	6	Collected in 2011
11	Dredger 1420-1	2014	7	collected in 2014
12	Dredger 1420-2	2014	7	collected in 2014
13	Dredger 1418-1	2014	6	collected in 2014
14	Dredger 1418-2	2014	6	collected in 2014
15	Dredger 1418-3	2014	6	collected in 2014
16	Dredger 1418-4	2014	6	collected in 2014
17	Dredger 1418-5	2014	6	collected in 2014
18	Dredger 1418-6	2014	6	collected in 2014
19	Dredger Padma	2016	5	Collected in 2016
20	Dredger Meghna	2016	5	Collected in 2016
21	Dredger Jamuna	2016	5	Collected in 2016
22	Amphibian dredger (4)	2017	4	Collected in 2017
	Total capacity of 25 dredgers		114	
	After collecting 20 dredgers in 2019		232.5	
	Total capacity		346.5	

Table 03:BIWTA dredger fleet data

BWDB's Current Dredger fleet:

Capacity/Size(inch)	Number
26	9
20	2
18	16
12	13
6	1
Total	41

Table 04:BWDB dredger fleet data

Number of Ancilliary Boat

Tug Boat	15
Work Boat	22
House Boat	32
Miscellaneous	5
Total	74

Table 05:BWDB ancilliary boat data

Availability of Dredgers & Their Capacity:

In order to plan the dredging work according with the demand, estimating the number of dredger accurately is a prerequisite.The summary of total number of dredgers[2] available currently under different owner is given below:

Serial no.	Dredger owner	Number	Remark
1.	BIWTA existing dredger fleet	21	14new,7old
2.	BWDB dredger fleet	30	9new, 21 old
3.	Private company	43	29 new,14old

Table 06 :Capacity of dredgers available in Bangladesh.

Total dredging capacity obtainable per year from these dredgers in our country is listed below:

Serial no.	Dredger owner	Number	Remark
1.	BIWTA	210	After delivery of 13 dredgers in 2015
2.	BWDB	250	Busy with own works
3.	Private dredging companies	140	To increase number of dredgers
	Total capacity	600	

Table 07 :.Number of dredgers available in Bangladesh.

From the above summary we can predict precisely the required number of dredgers along with

their capacity to satisfy the need in future.

Validation of New Dredgers Procurement:

A proposition has been made stating the procurement of new dredgers along with their size and quantity which is given below:

Serial no.	Dredger Type	Number	Remark
1	26" cutter suction dredger	10	To be deployed for big river dredging
2	20" cutter suction dredger	5	To be deployed for medium river dredging
3	18" cutter suction dredger	5	To be deployed for medium and small river dredging
	Total	20	

Table 08: Dredger types and numbers planned to procure.

Further requirement of dredgers (annual dredging capacity)-53.25 million m^3. Annual dredging capacity of proposed 20 dredgers - 26.50 million m^3.

Therefore, there would still be a shortage of dredger for BIWTA's planned river dredging works for next 11 years planning, which is expected to increase in the coming years.Finally it may be concluded that proposed 20 nos. of cutter suction dredgers,which is only about 50% of the present requirement, would only enable BIWTA to fulfil part of proposed dredging projects for inland waterway dredging. If private entrepreneurs come forward by increasing their dredging capacity substantially, then the decade long program can be achieved for improvement of inland waterways of Bangladesh.

4.Overview of dredging

- **Total Dredging Capacity:**

BIWTA	346.50 m^3
Private	500.00 lacs m^3
Total	846.50 lacs m^3

Table 09:BIWTA dredging capacity data

- **Dredging Required:**

Yearly Dredging Requirment	1655.10 lacs m^3
Yearly Dredging Capacity	846.50 lacs m^3
Shortage Capacity	808.60 lacs m^3

Table 10: Required dredging capacity

- To cover up shortage in dredging capacity BIWTA has taken another project "Procurement of 35 dredger and ancillary equipments".
- This project will increase BIWTA's dredger number to 80.
- The yearly dredging capacity of BIWTA will be 672 lacs m3.As a result,70% of BIWTA yearly dredging requirement will be met.
- To operate these dredgers ancillary craft boats like craneboat, houseboat is needed.

Manpower of a dredger:

Post Name	Number of employee
Leverman	2
Driver	2
Laskar	4/5
Greaser	1
Cook	1
Total	10/11

Table 11:Crew data of a dredger

Major Problems During Dredging Work:

- Lack of proper site survey before dredging.
- Cutter head often gets stuck to the river bed materials like plastic bag.
- Poor selection of dredger for the required work.
- The manpower is not properly trained.
- Lack of planning for handling dredge materials.
- Unplanned disposal of dredge materials which often cause environmental problem and erosion to river bed.
- Often dredger stops working suddenly due to lack of periodic maintenance.
- Lack of necessary manpower for maintenance work. As a result, maintenance is not done on a regular basis.

5.Estimation of Production Rate

The rate of production is the number of cubic yards of sediment per hour that are removed from the channel bottom by the dredge. From a cost estimation standpoint, this is an important factor simply because it will determine how much time it will take to complete the project. More time on the job means more wear on the machinery, more fuel used, and more pay for the workers. It is therefore imperative that the estimate of the production be as accurate as possible.

Production Rate depends on various factors, such as

1. Critical Velocity
2. Head Losses
3. Pump Characteristics Curves
4. Specific Gravity
5. Pump Speed
6. Materials factor
7. Bank factor
8. Discharge rate

Determination of Critical Velocity

As a grain of sediment travels through a pipeline, there is a certain velocity that the fluid around it must maintain in order to prevent the grain from falling to the bottom of the pipe and becoming stationary. If this velocity is not maintained, much of the sediment will settle and clog the pipeline. This condition is very undesirable, because it means shutting down the operation while the line is being unclogged. This “critical velocity” is a function of the specific gravity of the

sediment, the grain size, and the diameter of the pipe. Wilson et al. (1997) have presented a convenient method of determining the critical velocity using a nomograph .This nomograph has been entered into the spreadsheet and yields the critical velocity based on anassumed specific gravity of 2.65 (quartz) and median grain diameter of 0.4 mm. It is desirable to pump near the critical velocity based on the fact that head losses, power requirements, and pipeline wear are minimized at this value. However, pumping at a higher velocity results in higher production and less time on the job.Critical velocity is a function of the specific gravity of the sediment, the grain size and the diameter of the pipe.

According to Durand's formula Critical Velocity:

$Vc=FLx(2gD(s-1))^{0.5}$

Here,FL=Friction factor

g=acceleration due to gravity

D=Pipe inside diameter

S=Ratio of specific gravity of slurry to specific gravity of fluid

Vc=Critical velocity

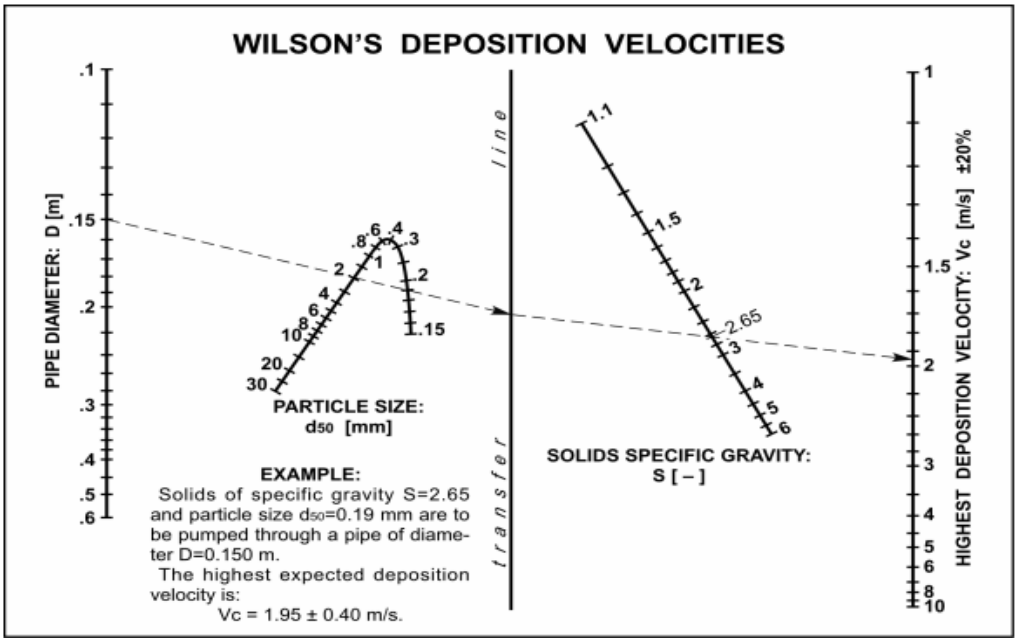

Figure 04:Relation of critical velocities with material factor and specific gravity

Determination of Head Losses

It is important to calculate the head losses for the system because this is how the maximum pumping distance for a particular pump is determined. The major component of the head losses of a system is the frictional head loss. There are also minor losses due to pipe joints and bends, but when are dealing with thousands of feet of pipe, the frictional losses far outweigh the rest. Head losses due to friction are determined in the program by the procedure outlined by Wilson et a1. (1997). Head loss is important to determine maximum pumping distance. Head loss mainly occur for bend,joint and friction.

According to Wilson et. al (1997) ,head loss per unit length is given by:

$$i_m=(fV^2/2gD)+0.22(S_s-1)V_{50}^{1.7}C_vV^{-1.7}$$

Here,

im=head loss per unit length,

D=inside diameter of pipe,

f=friction factor of water,

Ss=Specific gravity of solid,

Cv= percent volume of solid,

V= mean velocity of mixture

Dimensionless Pump Characteristics Curves

In order to create a dredge production program that can be applied to any size dredge pump, Herbich's (1992) method of using dimensionless parameters in the pump characteristics curves is incorporated. A typical set of pump characteristics curves shows the pump head, brake horsepower (or shaft horsepower), and pump efficiency as a function of discharge rate. In a dimensional format, these curves are only valid for a pump with the same specifications and operating at the same speed. However, when translated into a dimensionless format, the values of head (H), horsepower (P), and discharge (Q) may be calculated for any similar pump operating at any speed (Figure 4). Since efficiency (p) is a percentage. Herbich(1992) method of using

dimensionless parameter in the pump characteristic curve can be applied to any size dredge pump. The curve are valid in dimensional format for the pump with same specifications and speed only.

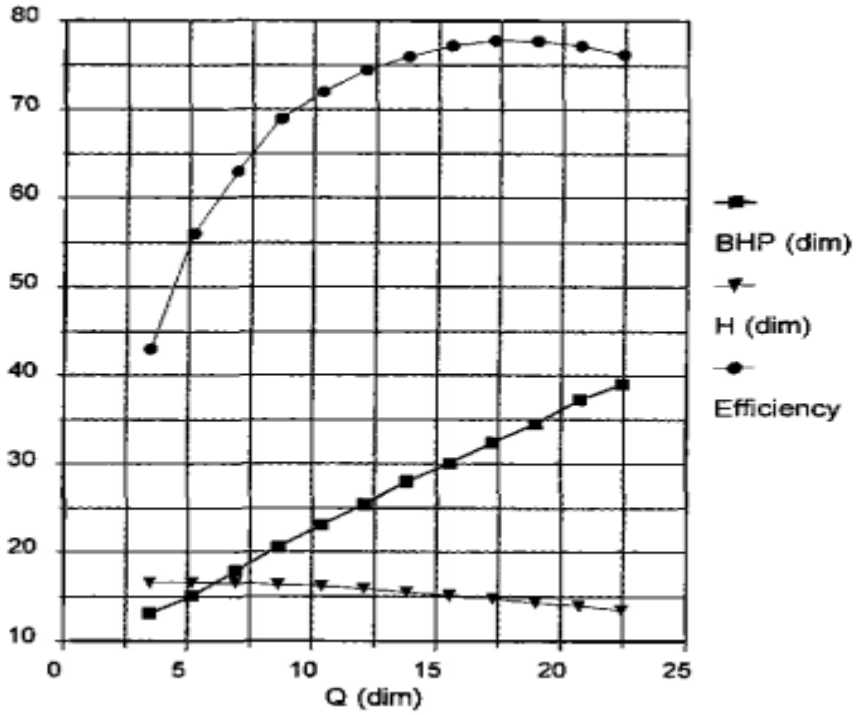

Figure 05 : Pump Characteristics Curves

From dimensionless pump characteristics curve we see that:

- The pump head decreases with the increase in flow rate.
- With the increase in the flow rate, the power consumption also increases.
- At a certain flow rate, efficiency is highest and this point is called best efficiency point.
- The dimensionless values are determined by:

  $H_{dim}=(gH/ w^2D^2)$

  $P_{dim}=(P/Pw^3D^5)$

  $Q_{dim}=(Q/wD^3)$

  Here,w is the pump speed in radian per second,

  D is impeller diameter,

  "dim" indicates the dimensionless quantity here.

Specific Gravity:

This value is assumed to be 1.4 initially, but may become smaller if the friction head losses are too large at this value. It is desirable to pump at the highest possible specific gravity, because this bears a greater concentration of solids by volume, which results in a higher production rate. This number changes incrementally down to a value of 1.2 in order to reduce head losses. It would be very inefficient to pump at a lower specific gravity than this, and a booster should be added at this point.

Impeller Diameter:

From examining the dimensionless pump curve equations, it is obvious that the impeller diameter of the pump must be specified in order for the user to obtain the proper values. The problem here lies in the fact that a number of different sized impellers may be used in any given pump. Contractors usually change the impeller depending on the length of pipeline used on a job. It is common practice to use a smaller impeller for shorter line lengths, thus conserving horsepower, and larger impellers for longer pipe lengths, thereby maximizing pump head. In order to simplify the input for this program, a list of typical impeller diameters is incorporated into the program, with different diameters listed for each dredge size and pipe length. These values were obtained from pump specifications listed in various pump manufacturers' catalogues and from personal communication

Pump Speed:

Each pump has its own most efficient operating speed, and this value does not vary nearly as much as the impeller size. With this in mind, another table of typical values is accessed by the program in order to obtain a suitable pump speed for its calculations. These values were obtained by examination of the pump characteristics curves provided by Georgia Iron Works and Mobile Pulley

Pump Size(inch)	Short Pipe Impeller dia(in)	RPM	Long pipe impeller dia(in)	RPM
12	36	535	42	500
14	42	510	50	485
16	44	480	56	450
18	48	450	60	425

20	56	425	68	400
22	62	400	72	385
24	68	385	84	360
26	74	360	88	335
28	80	350	94	315
30	84	325	98	300

Table 12 : Pump speed with pipe impeller diameter

Discharge rate:

The discharge rate chosen by the program is thirty percent of the range between the critical velocity and the threshold velocity. The threshold velocity is defined as the velocity above which the slurry becomes homogeneously mixed throughout the pipe. The pump head is then obtained from the dimensionless pump curves. If there is insufficient pump head to overcome the head losses and the specific gravity has already been incremented downward to the minimum, the program will prompt the user to add a booster to the system. The addition of a booster increases the head of the total system by the amount of pump head achieved by the booster. The above process is then repeated for the new system configuration. Once an acceptable number of boosters has been selected, the pump efficiency is obtained from the curves and the production is calculated using the formula stated above.

Materials factor:

This factor takes into account different viscosities, grain sizes, and in-situ consolidation to provide a description of relative ease of pumping. For instance, silt is easily excavated and, due to its tendency to remain in suspension, is easily transported. On the other hand, compacted clay is difficult to excavate and, once excavated, is difficult to pump through the line due to its

tendency to consolidate and create “clay balls.” Values for the USACE material factors used in CSDCEP are shown in Table 3. Since the sediment at a particular job site is seldom composed of a single type, the user is allowed to enter percentages of the whole of ten different sediment types to create a composite material factor. This factor is then applied to the calculated production rate. Therefore, the silt mentioned above has a factor of greater than one while the clay has a factor of less than one.

Material	Specific Gravity	Factor
Mud & silt	1.2	3.0
Mud & silt	1.3	2.5
Mud & silt	1.4	2.0
Loose sand	1.7	1.1
Loose sand	1.9	1.0
Compacted sand	2.0	0.9
Stiff clay	2.0	0.6
Compacted shell	2.3	0.5
Soft rock	2.4	0.4
Blasted rock	2.0	0.25

Table 13: Materials factor

Bank factor:

Another significant factor that must be considered is the bank height efficiency, or “bank factor.” In order to calculate the bank factor, the ratio of the cutter diameter to the bank height entered in the main page must be determined. This value is then used in conjunction with Figure 6 to obtain the bank factor. Two cells are lefl open for additional factors to be entered manually. Typical factors that may be necessary depending on the job site conditions are wind and wave factors. All of these factors are then applied to the production rate to yield the final production rate estimate.

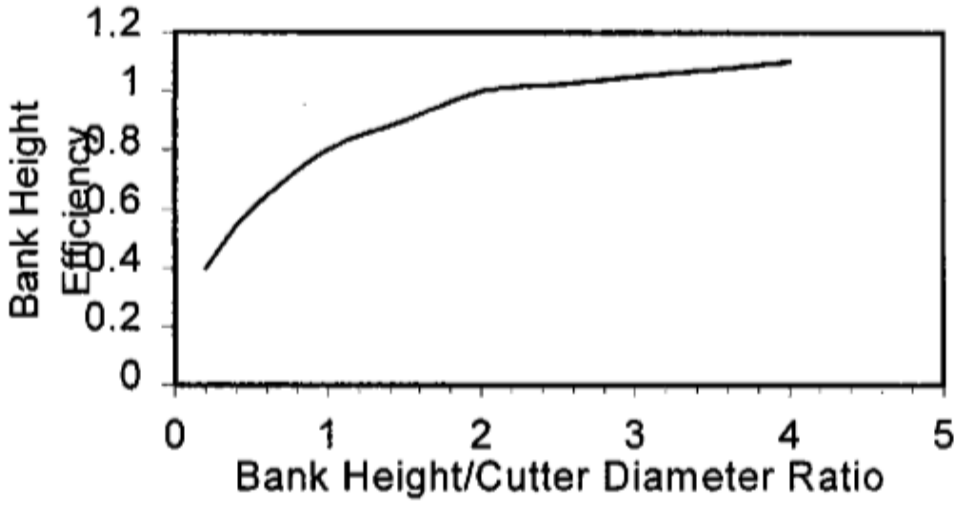

Figure 6. Bank factor determination chart (Scott, 1997).

Production Estimation:

P(Cubic yard/Hr)=Q X Cv X 0.297 X ɳ X DE

Where,

Q= Gallon per minute

Cv=Percent solid by volume

P=Production Rate

0.297=Conversion factor

ɳ=efficiency of the dredge pump

Steps to determine production rate:

1. Critical velocity is determined from grain size and pipe diameter, and operating discharge rate is calculated.
2. Head loss is determined using Wilson formula.
3. Corresponding pump head is determined from the pump characteristics curve.

4. If pump head>head loss then determine the production rate. It not then check for specific gravity of the slurry is minimum. For greater specific gravity, decrease specific gravity and repeat from step 2.If minimum then add booster pump.
5. After adding booster pump, set specific gravity to maximum.
6. Again, determine total head of the pump and booster system and repeat from step 4.

7.Conclusion and Recommendations

- The development of the thesis describe the current scenario of dredging in Bangladesh and also the estimation of production rate of a CSD(Cutter Suction Dredger).The thesis is done by drawing knowledge from different Government organization, newspaper, research paper and experienced person from dredging community. Based on the research, we found some common problems in a dredging operation which can be solved by applying the given recommendations.

- The manpower must go through proper training for operating and maintenance work.

- Proper site survey before dredging should be done.

- Dredger for a required project should be purchased according to the requirement of work and associate manpower needed.

- Proper planning to handle dredge materials should be ready before dredging.

- Different parts of the dredger should be checked on routine basis.

- In this thesis, production rate estimation of a CSD is also described. This theoretical process can be applied for CSD of any size and pipe length. As, it is a generalized theory

,it will not be fully accurate as the dredging nature is very diverse. The inaccuracy can be minimized by applying different corresponding factors of the dredging condition.

8.Referances

1. https://en.wikipedia.org/wiki/Dredging
2. https://www.startdredging.com/
3. www.dredgingtoday.com
4. https://www.google.com/search?q=navigable+waterway+in+bangladesh&oq=navi&aqs=chrome.0.69i59l2j69i57j0l3.2219j0j8&sourceid=chrome&ie=UTF-8
5. https://www.dhakatribune.com/business/economy/2020/06/22/river-dredging-made-costly-for-enhanced-tax-burden
6. https://www.thedailystar.net/city/news/govt-procure-55-dredgers-1748413
7. BIWTA.portal.gov.bd
8. BWDB.portal.gov.bd
9. Dredging and Land Reclamation in Bangladesh Perspective: A state of the Art Overview; Papia Sultana,Dr. MReazHasan Khondoker,Md. Mezbah Uddin1,Mohammad Irfan Uddin,Md. Abir Hossain
10. “COST AND PRODUCTION ESTIMATION FOR CUTTER SUCTION DREDGE” a thesis by MICHAEL WAYNE MIERTSCHIN , Texas A&M University